Appln. of: Mills
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AMENDMENTS TO THE CLAIMS

1. (Previously Presented) A method for limiting stress levels in an aircraft-powering turbofan assembly by controlling unstable movement of laminar-to-turbulent boundary layer transition on fan blades of the turbofan assembly during aircraft flight, said method comprising: including on a flying aircraft, an aircraft-powering turbofan assembly comprising multiple fan blades mounted on a fan disc and each of said fan blades having a leading edge, a trailing edge, and two side surfaces that comprise a high-pressure side surface and a low-pressure side surface, each blade also having a relatively long chord length, said turbofan assembly being configured such that a laminar-to-turbulent boundary layer transition occurs on the low-pressure side surface of each of said fan blades during flight; and wherein a plurality of said fan blades are each adapted to further comprise a laminar-to-turbulent boundary layer transition control feature at the low-pressure side surface of the respective fan blade, each of said control features initiating and positionally stabilizing a laminar-to-turbulent boundary layer transition to a location upon the respective fan blade between said control feature and the respective fan blade's trailing edge so that an aggregate limited stress occurring in the turbofan assembly at a mounting of the respective fan blade to the fan disc is substantially maintained below fifty megapascals during flight within the aircraft's operating envelope.

2. (Previously Presented) A method for limiting stress levels in an aircraft-powering turbofan assembly by controlling unstable movement of laminar-to-turbulent boundary layer transition on fan blades of the turbofan assembly during aircraft flight, said method comprising: including on a flying aircraft, an aircraft-powering turbofan assembly comprising multiple fan

blades mounted on a fan disc and each of said fan blades having a leading edge, a trailing edge, and two side surfaces that comprise a high-pressure side surface and a low-pressure side surface, each blade also having a relatively long chord length, said turbofan assembly being configured such that a laminar-to-turbulent boundary layer transition occurs on the low-pressure side surface of each of said fan blades during flight; and wherein a plurality of said fan blades are each adapted to further comprise a laminar-to-turbulent boundary layer transition control feature at the low-pressure side surface of the respective fan blade, each of said control features initiating and positionally stabilizing a laminar-to-turbulent boundary layer transition to a location upon the respective fan blade between said control feature and the respective fan blade's trailing edge so that an aggregate limited stress occurring in the turbofan assembly at a mounting of the respective fan blade to the fan disc is substantially maintained below twenty megapascals during flight within the aircraft's operating envelope.

3. (Previously Presented) A method for limiting stress levels in an aircraft-powering turbofan assembly by controlling unstable movement of laminar-to-turbulent boundary layer transition on fan blades of the turbofan assembly during aircraft flight, said method comprising:
including on a flying aircraft, an aircraft-powering turbofan assembly comprising multiple fan blades mounted on a fan disc and each of said fan blades having a leading edge, a trailing edge, and two side surfaces that comprise a high-pressure side surface and a low-pressure side surface, each blade also having a relatively long chord length, said turbofan assembly being configured such that a laminar-to-turbulent boundary layer transition occurs on the low-pressure side surface of each of said fan blades during flight, and wherein a plurality of said

fan blades are each adapted to further comprise a laminar-to-turbulent boundary layer transition control feature at the low-pressure side surface of the respective fan blade, each of said control features initiating and positionally stabilizing a laminar-to-turbulent boundary layer transition to a location upon the respective fan blade between said control feature and the respective fan blade's trailing edge so that an aggregate limited stress occurring in the turbofan assembly at a mounting of the respective fan blade to the fan disc is substantially maintained below ten megapascals during flight within the aircraft's operating envelope.

4. (Original) The method as recited in any one of claims 1-3, wherein said aggregate limited stress measured in the mounting of the respective fan blade to the fan disc is composed at least partially by fluctuating stresses.

5. (Original) The method as recited in claim 4, wherein said fluctuating stresses are at least partially caused by an unsteady aerodynamic force associated with an oscillatory chordwise translation of said boundary layer transition point along the chord of the respective fan blade.

6. (Original) The method as recited in any one of claims 1-3, further comprising: utilizing said laminar-to-turbulent boundary layer transition control feature in response to detecting structural degradation in a similarly configured turbofan assembly without the control feature.

7. (Original) The method as recited in any one of claims 1-3, further comprising: utilizing a strain gauge to assess the aggregate stress level experienced in the turbofan assembly

proximate the mounting of the respective fan blade to the fan disc during flight.

8. (Original) The method as recited in any one of claims 1-3, wherein said blades are operating under non-stall conditions.

9. (Original) The method as recited in any one of claims 1-3, wherein the flight envelope of said aircraft ranges from zero to seventy thousand feet pressure altitude and the fan blades are in stall-free operation.

10. (Original) The method as recited in any one of claims 1-3, further comprising: enabling a reduction in flight-time based inspection intervals of the turbofan assembly.

11. (Original) The method as recited in any one of claims 1-3, further comprising: enabling a reduction in flight-time based inspection intervals of constituent components of the turbofan assembly.

12. (Original) The method as recited in claim 11, wherein said fan blades are constituent components of the turbofan assembly.

13. (Original) The method as recited in claim 11; wherein said fan disc is a constituent component of the turbofan assembly.

14. (Original) The method as recited in any one of claims 1-3, further comprising: obtaining the approval of regulatory bodies for reduced frequency, flight-time based inspection intervals because of limited stress levels enabled by the utilization of the laminar-to-turbulent boundary layer transition control feature.

15. (Original) The method as recited in any one of claims 1-3, further comprising: maintaining a specific fuel consumption when said laminar-to-turbulent boundary layer transition control feature is included that is substantially equal to the specific fuel consumption of a similarly configured turbofan assembly without said control feature.

16. (Original) The method as recited in any one of claims 1-3, further comprising: communicating said limited stress levels in product promotions.

17. (Original) The method as recited in any one of claims 1-3, further comprising: communicating said limited stress levels for purposes of at least one of flight envelope expansion, product differentiation and sales promotion.

18-38. (Canceled)

39. (Currently Amended) The method as recited in any one of claims 1-3, wherein said laminar-to-turbulent boundary layer transition control feature is located on <u>said low-pressure side surface on</u> ~~at least one of said two side surfaces having~~ an essentially smooth surface

portion located between said leading and trailing edges and said feature being characterized by a surface deviation constituting a departure from said essentially smooth surface portion.

40. (Original) The method as recited in claim 39, wherein said departure from said essentially smooth surface portion is constituted by a reduced-elevation surficial portion, compared to said essentially smooth surface portion.

41. (Original) The method as recited in claim 39, wherein said departure from said essentially smooth surface portion is constituted by a raised-elevation surficial portion, compared to said essentially smooth surface portion.

42. (Currently Amended) The method as recited in claim 41, wherein said raised-elevation surficial portion is provided by applying an adhesive to ~~at least one of~~ said low-pressure ~~two~~ side surface~~surfaces~~, the thickness of said adhesive constituting the thickness of said raised-elevation surficial portion.

43. (Currently Amended) The method as recited in claim 41, wherein said raised-elevation surficial portion is provided by applying grit fixed to ~~at least one of~~ said low-pressure ~~two~~ side surface~~surfaces~~ using an adhesive, said grit establishing peak elevations of said raised-elevation surficial portion.

44. (Original) The method as recited in claim 41, wherein said raised-elevation surficial

portion is formed by at least one of bonding, mechanical, electrical, thermodynamic and chemical based techniques upon at least one of said two side surfaces.

45. (Original) The method as recited in claim 39, wherein said departure from said essentially smooth surface portion is greater than three inches long and is positioned chordwise between said fan blade leading edge and said fan blade trailing edge.

46. (Original) The method as recited in claim 39, wherein said departure from said essentially smooth surface portion is an elongate strip-shaped area of raised elevation having a length of three or less inches and positioned chordwise between said fan blade leading edge and said fan blade trailing edge.

47. (Original) The method as recited in claim 39, wherein said departure from said essentially smooth surface portion is an elongate strip-shaped area of raised elevation having a width of less than one-half inch.

48. (Original) The method as recited in claim 39, wherein said departure from said essentially smooth surface portion is an elongate strip-shaped area of raised elevation having a width of less than two-tenths of an inch.

49. (Original) The method as recited in claim 39, wherein said departure from said essentially smooth surface portion is an elongate strip-shaped area of raised elevation having a width of

approximately one-tenth of an inch.

50. (Original) The method as recited in claim 39, wherein said departure from said essentially smooth surface portion is an elongate strip-shaped area of raised elevation having a tip-end distanced approximately one-half inch from a tip of the respective turbofan blade.

51. (Original) The method as recited in claim 39, wherein said departure from said essentially smooth surface portion is an elongate strip-shaped area of raised elevation having a tip-end distanced at least one-half inch from a tip of the respective turbofan blade.

52. (Original) The method as recited in claim 39, wherein said departure from said essentially smooth surface portion is an elongate strip-shaped area of raised elevation positioned behind said leading edge and forward of the laminar to turbulent boundary layer transition point on the untreated fan blade.

53. (Original) A method for modifying an existing turbofan assembly having a plurality of unmodified fan blades mounted on a fan disc, each of said plurality of unmodified fan blades having a leading edge, a trailing edge, a first side and a second side, the method comprising the steps of: determining a range of translation of an unstable transition point between a laminar and a turbulent boundary layer on at least one of the first side and the second side of at least one of said plurality of unmodified fan blades, the range of translation of the unstable transition point having a foremost position closest to the leading edge; and modifying the existing

turbofan assembly by positioning a boundary layer transition point stabilizing element on at least one of the first side and the second side of at least one of said plurality of unmodified fan blades between the leading edge and the foremost position of the unstable transition point, thereby reducing the range of translation of the unstable transition point between the laminar and the turbulent boundary layer by initializing transition from a laminar to turbulent boundary layer upstream of the determined range of translation and thereby minimizing the range of translation of said initiated transition boundary point during use of the modified turbofan assembly, and reducing aggregate stresses occurring at a mounting of at least one of said plurality of modified fan blades to the fan disc in the modified turbofan assembly to below a predetermined threshold during use of the modified turbofan assembly.

54. (Original) The method as recited in claim 53, wherein the predetermined threshold is fifty megapascals during use of the turbo fan assembly.

55. (Original) The method as recited in claim 53, wherein the predetermined threshold is twenty megapascals during use of the turbo fan assembly.

56. (Original) The method as recited in claim 53, wherein the predetermined threshold is ten megapascals during use of the turbo fan assembly.

57. (Original) The method as recited in claim 53, wherein the unstable translation of said laminar to turbulent boundary layer transition point includes an oscillatory chordwise

translation on at least one of said plurality of unmodified fan blades.

58. (Original) The method as recited in claim 53, further comprising the step of enabling a reduction in frequency of flight-time based inspections of the existing turbofan assembly.

59. (Original) The method as recited in claim 53, further comprising the step of expanding a flight envelope of the modified turbofan assembly.

60. (Original) The method as recited in claim 53, wherein said transition stabilizing element is at least one of (1) a vortex generator and (2) a turbulator and (3) a transition strip in the form of a raised elevation above a smooth surface of each of said plurality of fan blades and (4) a transition strip in the form of a recessed elevation below a smooth surface of each of said plurality of fan blades.

61. (Original) The method as recited in claim 60, wherein said raised elevation is provided by applying an adhesive to at least one of the first side and the second side, a thickness of said adhesive constituting the thickness of said raised-elevation.

62. (Original) The method as recited in claim 60, wherein said raised elevation is provided by applying grit to at least one of the first side and the second side using an adhesive, said grit establishing peak elevations of said raised-elevation.

63. (Original) The method as recited in claim 60, wherein said raised and/or recessed elevations are created by at least one of bonding, spraying, forming, or the use of any mechanical, electrical, thermodynamic and/or chemical based procedure used to develop said raised or recessed elevations upon at least one of the two side surfaces.

64. (Original) The method as recited in claim 60, wherein said raised elevation and said recessed elevation include an elongate strip-shaped area having a length of greater than three inches.

65. (Original) The method as recited in claim 60, wherein said raised elevation and said recessed elevation include an elongate strip-shaped area having a length of three inches or less.

66. (Original) The method as recited in claim 60, wherein said raised elevation and said recessed elevation include an elongate strip-shaped area having a width of less than one-half inch.

67. (Original) The method as recited in claim 60, wherein said raised elevation and said recessed elevation include an elongate strip-shaped area having a width of less than two-tenths of an inch,

68. (Original) The method as recited in claim 60, wherein said raised elevation and said recessed elevation include an elongate strip-shaped area having a width of approximately one-

tenth of an inch.

69. (Original) The method as recited in claim 60, wherein said raised elevation and said recessed elevation include an elongate strip-shaped area having a tip-end distanced approximately one-half inch or less from a tip of each of said plurality of fan blades.

70. (Original) The method as recited in claim 60, wherein said raised elevation and said recessed elevation include an elongate strip-shaped area having a tip-end distanced at least one-half inch from a tip of each of said plurality of fan blades.